

Irrigation management and variety effects on rice grain Arsenic levels in Uruguay


 Instituto Nacional de Investigación Agropecuaria
URUGUAY

 G. Carracelas¹, J. Hornbuckle², M. Verger³, R. Huertas⁴, S. Riccetto⁵, F. Campos⁶ and A. Roel⁷
¹National Institute of Agricultural Research (INIA), Uruguay. gcarracelas@inia.org.uy

²Deakin University. Faculty of Sc. Eng. & Env. CeRRF. Australia. j.hornbuckle@deakin.edu.au

³Technological Laboratory of Uruguay (LATU), Uruguay. mverger@latu.org.uy

⁴Technological Laboratory of Uruguay (LATU), Uruguay. rhuertas@latu.org.uy

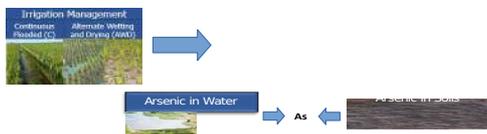
⁵National Institute of Agricultural Research (INIA), Uruguay. sarariccetto@gmail.com

⁶National Institute of Agricultural Research (INIA), Uruguay. fefocampos2003@hotmail.com

⁷National Institute of Agricultural Research (INIA), Uruguay. aroel@inia.org.uy

Introduction

Rice is the most important staple component of the human diet worldwide. The higher amounts of arsenic accumulation in its grain in relation to other crops, determines a potential toxicity risk to humans. The rice sector is facing the challenge of achieving high yields to meet the increasing global food demand while maintaining food safety.



Objective

This research project aimed to determine the inorganic arsenic (iAs) accumulation in rice grain in two contrasting soils sites commonly used for rice production in Uruguay. Another objective was to identify alternative irrigation management techniques to traditional flooding that could be used to limit or reduce the iAs accumulation in grain and to determine differences in iAs levels within the most commonly planted rice varieties in Uruguay.

Material and Methods

Experiments (5) were conducted in 2 experimental units (PF and PdL) over 3 rice growing seasons (October to March) from 2014 until 2017. Experimental design was a split plot with 4 blocks, including two irrigation treatments: continuous flooded (C) and alternate wetting and drying (AWD) and 4 varieties (Figure 1). In treatment C, flooding started 15 days after emergence and maintained throughout all the crop cycle with a water layer of 10 cm. The AWD treatment allowed the soil to dry periodically (water depletion of 50% of soil available water) until panicle initiation. After this period, it was managed as C. The split plots included different varieties: Indicas (INIA Merin, INIA Olimar, El Paso 144) and Japonicas (INIA Parao, INIA Tacuarí). Statistical analyses were all performed in R software using the emmeans and nlme packages (R Core Team, 2018).

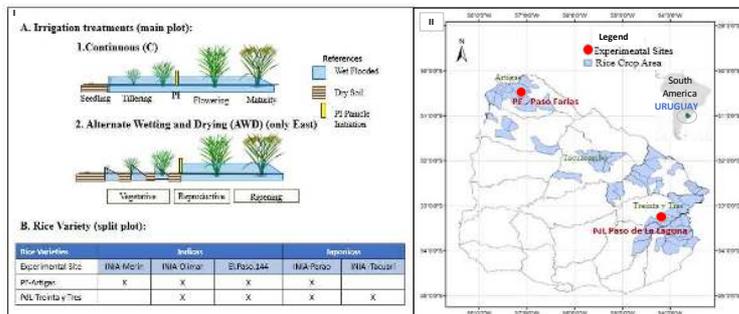


Figure 1. I. Irrigation treatments (C - AWD) and Varieties (Indicas and Japonicas) tested in Paso Farias (PF) North and Paso de la Laguna (PdL) East. II. Location of the two experimental sites in Uruguay.

Results

Arsenic levels registered in Irrigation water and soils were found to be very low, which resulted in low levels of iAs accumulated in rice grain at both sites. Total As in soils were well below the Canadian limit for agricultural soils of 12 mg kg⁻¹ (CCME) and As in water were below the limited restriction values for irrigation surface water of 0.05 mg L⁻¹ (Class 2a) and 0.005 mg L⁻¹ (Class3) (Decreto N° 253/79, 1979).

Table 1. Arsenic in soils, water and iAs levels accumulated in polished rice grain by site.

Classification criteria	Arsenic in Soils at sowing		Arsenic in water (As mg L ⁻¹)	Inorganic Arsenic in Grain (iAs mg kg ⁻¹)
	Total Arsenic (tAs mg kg ⁻¹)	Bioavailable Arsenic (bioAs µg L ⁻¹)		
Site				
PdL	3.62 a	30.30 a	0.00272 a	0.091 a
PF	2.14 b	15.21 b	0.00176 b	0.043 b
Average	2.88	22.76	0.00224	0.067
CV%	27.56	15.4	22.72	4.524
P<0.05	***	***	***	***

Means followed by different letters are significantly different with a probability less than 5% (P < 0.05). Signif. codes: *** 0.001 *** 0.01 ** 0.05; NS: non-significant differences. CV: coefficient of variation.

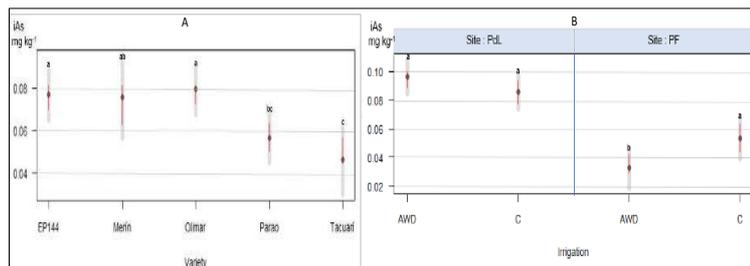


Figure 2. Inorganic arsenic accumulated in polished rice grain for: A. Varieties and B. Irrigation management by site. Black dots represent means, red lines indicate confidence interval by Tukey. Different letters indicate significant differences within treatments with a probability less than 5%.

AWD irrigation treatment resulted in a significant yield reduction of 14% in relation to C. Japonica cultivars registered the lowest rice grain yields.

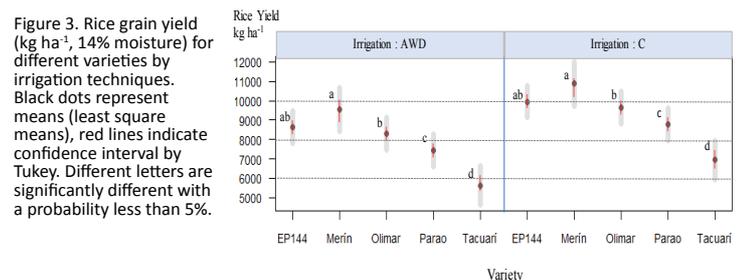


Figure 3. Rice grain yield (kg ha⁻¹, 14% moisture) for different varieties by irrigation techniques. Black dots represent means (least square means), red lines indicate confidence interval by Tukey. Different letters are significantly different with a probability less than 5%.

Conclusions

Inorganic Arsenic levels (iAs) accumulated in polished rice grain grown in Uruguay (average 0.07 mg kg⁻¹) were found to be well below the limit proposed by the CODEX international standards of 0.20 mg.kg⁻¹ (FAO and WHO, 2019), even under the traditional continuous irrigation technique.

The implementation of AWD in certain soil types can further reduce the iAs accumulation in rice grain.

Japonica varieties had a lower accumulation of iAs in rice grain, in comparison with *Indicas* at both sites.

References

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